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Using the Gravity Model to Estimate the Costs of Protection

Howard J. Wall

The United States, along with almost every other country in the world, maintains significant restrictions on the movement of goods across international borders. Although the recent Uruguay round of the General Agreement on Tariffs and Trade (GATT) resulted in a general lowering of tariffs and a broadening of goods and countries covered by the agreement, free trade remains elusive. Strong growth in the United States in recent years has kept protectionist pressures at bay, but recent calls for restrictions on steel and other imports suggest that protectionism in the United States has been dormant but is not dead.

When a country restricts imports, foreign producers are disadvantaged relative to their domestic competitors, and the volume of trade is reduced. This prevents both importing and exporting countries from realizing all of the gains from international trade, as resources will be diverted from industries where there are comparative advantages. The objective of this paper is to provide new estimates of the effects of protectionism on the volume of U.S. trade, and to obtain rough estimates of the resulting welfare effects.

Table 1 summarizes the variety of trade barriers imposed by the United States and its trading partners in the rest

Table 1

Summary of Trade Barriers in the United States and the ROW

Trade Barriers	***ROW Against U.S. Goods*** [a]	***United States Against ROW Goods*** [b]
Import policies	Tariffs and other import charges, quantitative restrictions, import licensing, customs restrictions	High tariffs on selected goods, quantitative restrictions, unilateralism (section 301, "super 301," and "special 301")
Administrative and other barriers	Standards, testing, labeling, and certification requirements	Onerous invoice requirements, user fees, merchandise processing fees, harbor maintenance tax, non-adherence to international product standards
Government procurement	"Buy national" policies and closed bidding	Buy America Act of 1933, state-level "buy local" legislation
Intellectual property	Inadequate patent, copyright, and trademark regimes	
Other	Bribery and corruption, tolerance of anti-competitive practices	Arbitrary anti-dumping legislation

[a] From 1998 National Trade Estimate Report on Foreign Trade Barriers, USTR.

[b] From Market Access Sectoral and Trade Barriers Database, European Commission Directorate-General I.

of the world (ROW).[1] Common to United States and ROW protectionism is the application of the traditional import policies of import tariffs and quantitative restrictions. The most important difference between U.S. and ROW policies is the prominence in the United States of unilateral actions via the so-called "section 301 family" of legislation. These unilateral actions, which are outside of multilateral arrangements in place, threaten and punish trading partners that the United States deems to be trading "unfairly." Where ROW protection stands out is in the tendency for developing and newly industrialized countries to have high levels of tariffs, red tape, and corruption, as well as little or no protection of intellectual property rights.

Whereas the theoretical calculations of the effects and costs of trade protection are well-established, the empirical estimates of the costs have been surprisingly small, especially considering the effort that economists spend decrying trade protection. For example, studies surveyed by Feenstra (1992) found the yearly cost of U.S. protection for years around 1985 to be $15.2 to 29.6 billion, or only 0.38 to 0.73 percent of gross domestic product (GDP). This is similar to a more recent study by Hufbauer and Elliot (1994), and to earlier studies surveyed by Baldwin (1984).

De Melo and Tarr (1992) argue that one reason for these small estimated costs is the use of a partial equilibrium method. In partial equilibrium models, the cost of protection in each of a large number of sectors is estimated separately, without regard to the cross-sector effects. The results for each protected sector are then simply summed to obtain the aggregate effect of protection. De Melo and Tarr propose an alternative general equilibrium model that takes explicit account of the consequences that the imposition of import protection in one sector has on other sectors in the economy. They find that the welfare cost of protection from quantitative restrictions alone was $25 to 29 billion in 1984.

A practical difficulty shared by previous approaches is their extremely high informational requirements. To estimate economy-wide costs of protection, one must know a great deal about each of the many sectors of the economy, and about the myriad of import policies and the avenues by which they can affect welfare. This is compounded by the use of unilateral antidumping actions, which can affect markets even when no actual duty or restriction is imposed.[2]

I outline an alternative estimation method that has a much lower informational requirement, while also having the advantages of general equilibrium approaches in estimating the effects of protection on the volume of trade. Specifically, I outline a gravity model of international trade that requires one to know for a cross-section of countries only their levels of bilateral trade, their GDPs, and a measure of the average level of trade protection.

Section II outlines the use of gravity models in international trade, and suggests a version of the model that allows trading relationships to differ across trading pairs. Section III estimates the gravity model using U.S. import and export data for 1994-96, and calculates the effect of U.S. and ROW protection of U.S. trade volumes. Section IV translates these estimates into rough calculations of the welfare costs of U.S. protection, and Section V concludes.

USING THE GRAVITY MODEL

The gravity model was first applied to international trade by Tinbergen (1962) and Pöynöhen (1963), but it has a long history in the social sciences. Since the latter half of the nineteenth century, it has been used to explain social flows, primarily migration, in terms of the "gravitational forces of human interaction." Its name is derived from its passing similarity to Newtonian physics, in that large economic entities such as countries or cities are said to exert pulling power on people or their products. The simplest form of the gravity model for international trade posits that the volume of exports between any two trading partners is an increasing function of their national incomes, and a decreasing function of the

[1] Detailed country-by-country descriptions of trade barriers are available at the web site of the United States Trade Representative <www.ustr.gov>. The State Department and World Trade Organization web sites <www.state.gov> and <www.wto.org> also have country reports of trade practices. For detailed descriptions of U.S. restrictions against the ROW, see the European Commission Directorate-General I's *Market Access Sectoral and Trade Barriers Database* <europa.eu.int/comm/dg01/dg1.htm>

[2] See Staiger and Wolak (1994) for a discussion and empirical evidence.

distance between them. Specifically, using Y_i and Y_j to denote national incomes, and D_{ij} to denote distance, the flow of goods from country *i* to country *j* is expressed in log-linear form as

$$(1) \quad \ln X_{ij} = \alpha + \beta \ln Y_i + \gamma \ln Y_j - \delta \ln D_{ij},$$

where $\alpha, \beta, \gamma,$ and δ are positive constants. This is then estimated using a cross-section of trading countries taken across a single year or pooled over several years, typically measuring D_{ij} by the distance between the capital cities. It also is common to use dummy variables to capture contiguity effects, cultural and historical similarities, and regional integration.[3]

Although widely used because of its perceived empirical success (usually taken to mean a high R^2), the gravity model had lacked rigorous theoretical underpinnings, and was long criticized for being *ad hoc*. Recently though, Deardorff (1998) has shown that the gravity equation is consistent with several variants of the Ricardian and Heckschser-Ohlin models. This is in addition to earlier work by Anderson (1979) and Bergstrand (1985) who derived gravity equations from trade models with product differentiation and increasing returns to scale.

Although theoretical foundations have been established, the empirical application of the gravity model is still rather basic. As demonstrated by Cheng and Wall (1999), despite providing a high R^2, the standard estimation method tends to underestimate trade between high-volume traders, and overestimate it between low-volume traders. They attribute this to heterogeneity bias, which they address by relaxing the restriction that the intercept of the gravity equation must be the same for all trading partners.[4] Their fixed-effects method, which I will use in this study, assumes instead that there are fixed factors that can make the intercept of the gravity equation different for each trading pair.

The first of the two main benefits of the fixed-effects method is that it controls for omitted variables that are unobservable or difficult to measure. In terms of standard trade models, such variables might reflect the relative preference that an importing country's consumers have for an exporter's goods. For example, if U.S. consumers have a stronger preference for British-made goods over French-made goods, then all else equal, the United States will import more from Britain than from France. In addition to such considerations, other fixed factors such as historical links, cultural similarities, etc., that are difficult to quantify are captured by each trading-pair intercept.

The second advantage of the fixed-effects method is that fixed economic-distance variables are subsumed into the trading-pair intercept, instead of being proxied for by the geographic distance between the capital cities of the trading partners. This is particularly important for studies that include the United States, which has several economic centers on and between two distant coasts. For example, given that the West Coast of the United States is thousands of kilometers closer to Japan than is the East Coast, it is difficult to justify using the distance between Tokyo and Washington, D.C., to represent the trading distance between the two countries. Even correcting for this mismeasurement, it may not be a good measure of economic distance, because geographic distance ignores transport difficulties. For example, the geographic distance between New York and Moscow (7533 km) is shorter than that between Tokyo and Los Angeles (8816 km), but it is difficult to believe that Russia is economically nearer to the United States than is Japan.

THE EMPIRICAL RESULTS

I perform two least squares estimations of the gravity model, the first is under the restriction that the trading-pair intercepts are all equal, and the second relaxes this restriction. Both estimations retain the standard restriction that the coefficients on the other variables are the same for all countries. The restricted regression equation is

3 See Oguledo and MacPhee (1994) for a summary of earlier models and results in the literature.

4 Bayoumi and Eichengreen (1997) also allow for different intercepts, but with a different method.

Table 2

Regression Results for Gravity Model of U.S. Trade; Dependent Variable: Log of Bilateral Merchandise Exports

	Restricted Model	*Unrestricted Model*
Constant	-8.930 (-8.48)	—*
Origin GDP	0.922 (35.38)	0.446 (1.94)
Destination GDP	0.930 (29.90)	0.421 (1.83)
Distance	-0.942 (-10.03)	—
Trade policy index	-0.042 (-0.69)	-0.154 (-4.01)
R^2	0.750	0.953
Log-likelihood	-791.89	-364.86
Observations	510	510
Degrees of freedom	505	422

The *t*-statistics are in parentheses. *For space considerations the 85 trading-pair intercepts are not reported here.

$$\ln X_{ijt} = \alpha + \beta \ln Y_{it} + \gamma \ln Y_{jt} + \delta \ln D_{ij} + \lambda T_{jt} + \varepsilon_{ijt} \ , \tag{2}$$

where T_{jt} is the trade policy index for the importing country at time *t*, and ε_{ijt} is an error term. The unrestricted regression equation is

$$\ln X_{ijt} = \alpha_{ij} + \beta \ln Y_{it} + \gamma \ln Y_{jt} + \lambda T_{jt} + \varepsilon_{ijt}, \tag{3}$$

where α_{ij} is the trading-pair intercept, and the distance variable is subsumed into the intercept.

The data set is a panel of U.S. merchandise imports and exports to and from 85 countries for the years 1994-96. The 85 countries, listed in the appendix, are all the countries for which all variables are available for all three years. The trade data come from the Census Bureau's U.S. Import and Export History database, and the national income data are GDPs at market prices in U.S. dollars, taken from the World Bank's *World Tables*. Nominal GDP and trade data are converted into constant chained 1992 dollars. The distance variable is simply the great-circle distance between Washington, D.C., and the capital city of the trading partner.

Whereas it is relatively straightforward to gather data for bilateral trade, GDP, and distance, the extensive use of non-tariff and administrative barriers makes it difficult to quantify average levels of protection, and the oft-cited average tariff level is clearly inadequate. Instead, I use the trade policy index that is part of the Heritage Foundation's *Index of Economic Freedom*, the most recent of which is found in Johnson, Holmes, and Kirkpatrick (1998). When determining the score for a country, the authors considered average tariff levels along with descriptions from other sources of non-tariff policies, which are otherwise difficult or impossible to quantify.[5] The index rates countries on a scale of one to five, where numerical scores correspond respectively to levels of import protection: very low, low, moderate, high, and very high.[6] Because the information used to determine the index is collected during the year prior to its publication, the index is lagged in the estimation. Also, as the North American Free Trade Agreement (NAFTA) was in force during the sample period, the index takes the value of one for U.S. trade with Mexico and Canada.

5 The 1996 scores for the 86 countries included in this study appear in the appendix.

6 I would like to thank Bryan Johnson of the Heritage Foundation for providing me with the data tables.

Table 3

Effects of Protectionism on U.S. Merchandise Imports and Exports; 1996 (1992 dollars)

	Actual U.S. Trade ($ millions)	Effect of Protection ($ millions)	Effect as Percent of Trade	Effect as Percent of U.S. GDP
U.S. Imports (Non-NAFTA)				
From countries in sample	435,336	-67,190	-15.4	
From all countries	723,150	-111,611	-15.4	-1.66
U.S. Exports (Non-NAFTA)				
To countries in sample	295,761	-77,345	-26.2	
To all countries	498,754	-130,430	-26.2	-1.94

The least squares regression results summarized by Table 2 indicate that both versions of the model perform relatively well, and that the estimated coefficients have the expected signs. Note, however, that there are significant differences between the restricted and unrestricted versions. When the restriction on the intercept term is removed, the coefficients on the GDPs become much smaller, and that on trade policy becomes larger and statistically significant. A likelihood ratio test rejects the null hypothesis that the two models are statistically the same. The conclusion, therefore, is that the restriction on the intercepts cannot be supported statistically.

Focusing on the unrestricted model then, all else constant, a 10 percent increase in a country's national income tends to be associated with a 4.2 to 4.5 percent increase in the volume of merchandise trade between the country and its trading partners. Also, for each one-point increase in a country's trade policy index, merchandise imports tend to fall by 15.4 percent.

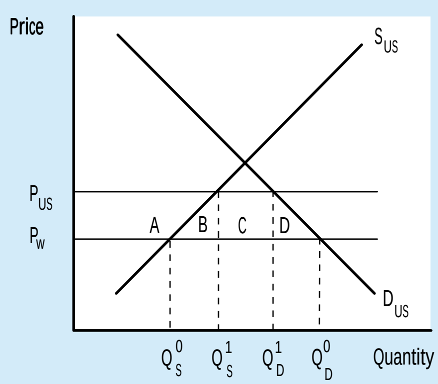
To calculate the total effect of U.S. protection on U.S. merchandise imports, and ROW protection on U.S. merchandise exports, I apply the results to the actual levels of trade and protection in the sample. I do so by taking the data for 1996, and calculating (i), the amount that the United States would have imported from each country if the United States had a trade policy index of one; and (ii), the amount that the United States would have exported to each country if every export market had a trade policy index of one. Because the United States already has free trade (or close to it) with Canada and Mexico, they are eliminated from the calculations. To extrapolate these calculations to the level of aggregate trade, I assume that the effect of protection as a percentage of trade is the same for non-NAFTA countries within and outside of the sample. Table 3 summarizes these calculations.

The United States imported over $723 billion in merchandise from non-NAFTA countries in 1996, but would have imported over $111 billion more if it had a policy of free trade. In percentage terms, U.S. protectionism decreased its merchandise imports from non-NAFTA countries by 15.4 percent, which amounted to about 1.66 percent of U.S. GDP. In the same year, the United States exported nearly half a trillion dollars of merchandise, but would have exported $130 billion more if the rest of the world had free trade. This was a 26.2 percent loss of U.S. merchandise exports to non-NAFTA countries, which was 1.94 percent of U.S. GDP. Including trade with Mexico and Canada, U.S. protection decreased its imports by 10.4 percent, whereas ROW protection decreased U.S. exports by 17.0 percent. This estimated effect of protection is much higher than found in previous

WELFARE COSTS OF IMPORT PROTECTION

Below is a brief description of the standard partial equilibrium dissection of the welfare effects of import protection under perfect competition. It begins with an analysis of import tariffs, which can be adapted easily to look at the effects of other forms of trade protection.

The figure below illustrates the market for a hypothetical good that the U.S. imports from the ROW, and S_{US} and D_{US} are the U.S. supply and demand curves. Under free trade, the good is imported at the world price, P_w. At this price, the United States consumes Q_D^0 and produces Q_S^0, and the difference, $Q_D^0 - Q_S^0$, is imported from the ROW. Assume that the United States levies a tariff of *t* per unit imports, and that the tariff does not affect the world price. After the tariff is levied, the price in the United States becomes $P_{US} = P_{w+t}$, causing consumption to fall to Q_D^1, and production to rise to Q_S^1. The tariff therefore decreases the level of imports to $Q_D^1 - Q_S^1$. Clearly, consumers are worse off because they pay a higher price and consume less of the good, whereas producers are better off because they produce more of the good at a higher price.



Imposition of the tariff means that consumer surplus is reduced by the area A+B+C+D. Part of this, area A, is transferred to firms as a gain in producer surplus, and another part, area C, goes to the government as tariff revenue. Because areas A and C are simply transfers within the United States, they do not represent a change in national welfare. However, parts of the consumer loss, areas B and D, are not transferred to anyone, and are therefore deadweight losses measuring the net decrease in national welfare due to the tariff. Area B is a deadweight production loss due to overproduction of the good, and area D is a deadweight consumption loss due to underconsumption of the good.

The figure also can be used to describe the welfare effects of a quantitative restriction (QR) such as an import quota or voluntary restraint agreement. Assume that the United States imposes a QR that limits imports to the same level as would result under the tariff described above. The price in the United States would rise to P_{US}, where the quantity supplied by U.S. and ROW producers would equal the quantity demanded by U.S. consumers. As with an import tariff, this reduces consumer surplus by A+B+C+D, with a gain in producer surplus of A, and deadweight losses of B and D. However, unlike the case of an import tariff, area C does not necessarily represent revenue collected by the government, as it measures the *quota rents* created by the difference between the U.S. price and the world price. If there is no government revenue-raising mechanism associated with the QR, then all quota rents are captured by ROW producers, and area C represents a net welfare loss to the economy. However, revenue might be raised through the sale of quota licenses, or by imposing an import tariff alongside the QR. Using θ to denote the government's share of the quota rents, the total net welfare loss from a quantitative restriction is therefore $B + D + (1-\theta)C$.

Although the above analysis focuses on import tariffs and QRs, it is readily adaptable to other commonly employed forms of trade protection. For example, administrative fees imposed on ROW producers have the same effects as tariffs. Also, the threat of section 301 actions can have the same welfare effects as a QR in which all quota rents are transferred overseas. This is because the mere threat of unilateral action can lead importers to raise their prices in the United States to avoid triggering anti-dumping cases.

studies such as Hufbauer and Elliot (1994) who use the standard method of adding up the partial equilibrium effects across protected industries. Their results for 1990 suggest that complete liberalization of U.S. trade would have lead to a 6 percent increase in imports.[7]

THE WELFARE COSTS OF U.S. PROTECTION

A disadvantage of the gravity model is that it is unsuitable for direct estimates of welfare costs. Studies such as Hufbauer and Elliot (1994) use industry-level data to estimate supply and demand functions, and therefore are readily useful for welfare calculations. However, as the gravity model is only a prediction of aggregate trade flows, without any information about the underlying supply and demand conditions, such welfare calculations are elusive.

To substitute for this, crude calculations can be obtained using Hufbauer and Elliot's results. According to their results, on average, a $1 decrease in imports due to import protection translates into a $2 decrease in consumer surplus. Also, of each $1 that consumers lose, $0.49 is transferred to producers, and $0.11 is deadweight loss. Applying these numbers to the estimates above, import protection in 1996 cost U.S. consumers $223.4 billion, or 3.3 percent of GDP. Of this, $109.1 billion was transferred to producers, and $24.5 billion was deadweight loss. The remainder is comprised of tariff revenue and quota rents. Subtracting the actual revenue collected in customs duties from this, the quota rents not captured by the U.S. government amounted to $72.8 billion.[8] If all of these quota rents were transferred to ROW producers, the net welfare cost of U.S. protection in 1996 was $97.3 billion, or 1.45 percent of GDP.

This estimate does not account for terms of trade effects, which occur because the size of the United States in the world market means that it can shift part of the burden of tariffs onto ROW producers. Using the Hufbauer and Elliot estimate of an average decrease of 9 percent in the world prices of protected goods, the terms of trade gain to the United States from its tariffs was only $1.5 billion, making the welfare cost of U.S. protection 1.43 percent of GDP in 1996. Note that the terms of trade effect is potentially much higher than this. However, because non-tariff protection is so prevalent, most of the quota rents created by U.S. protection are shifted to overseas producers, instead of to the U.S. government as tariff revenue.

Unfortunately, because there is no study of U.S. export markets analogous to Hufbauer and Elliot's study, such straightforward welfare estimates of the cost of ROW protection on the United States are not possible. Note though that because the effects of ROW protection on U.S. exports is similar in order of magnitude to the effects of U.S. protection on U.S. imports, it is tempting to conclude that the welfare costs are also of the same order of magnitude. However, recall that because of the prevalence of non-tariff barriers, much of the cost of U.S. protection is the transfer of quota rents to ROW producers. If ROW

[7] I obtain this figure by assuming that the total percentage effect on output in the 21 industries they examine, which represented about 10 percent of imports, was the same for all other industries in which protection was imposed. Also note that about one-third of imports in 1990 faced no import restriction.

[8] The *Statistical Abstract of the United States 1998* reports that real 1996 tariff revenue was $16.9 billion.

protection results in similar transfer to U.S. producers, the welfare effects of ROW protection on the United States would be mitigated significantly.

CONCLUSIONS

The objective of this paper was to provide new estimates of the effects of protectionism on the volume of U.S. trade, and to obtain rough estimates of the resulting welfare effects. In doing so, I outlined a new approach that uses a gravity model, which is capable of accounting for the general equilibrium effects while having a relatively low informational requirement. I also used a specific form of the gravity model, which allowed for trading-pair heterogeneity and which was statistically superior to the standard model. The method also included the use of a partly subjective trade policy index that accounts for forms of protection that are difficult to quantify, such as administrative barriers, unilateralism, procurement restrictions, corruption, etc.

Using this approach, I estimated that protectionism in the rest of the world meant that U.S. exports were 26.2 percent lower in 1996 than they would have been otherwise. I also estimated that U.S. protectionism decreased U.S. imports from non-NAFTA countries by 15.4 percent per year, which had a net welfare cost amounting to 1.45 percent of GDP in 1996. The primary source of this welfare loss was the transfer of quota rents overseas, rather than deadweight efficiency losses. Because the method I used takes into account general equilibrium effects and non-tariff and non-quota trade barriers, these estimates are much higher than those found in previous studies.

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